22. Development of ozone technology fish storage systems for improving quality fish production

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Modeling of Electric Potential Distribution in EHD Flow Zone Utilizing Pin-Multi Ring Consentric Electrodes

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Abstract

A modeling simulation has been carried out for the electric potential distribution in zones EHD flow generated using pin-multi concentric ring electrodes and used as a comparator pin-single ring electrode. The pin needle was made from stainless steel with a tip diameter of 0.01 mm. The multi ring electrodes was constracted by dual concentric rings with a metal material connected to each other and each ring has a diameter of 24 mm and 16 mm in width and the ring thickness were 2 mm and 1 mm. Single ring electrode has a diameter, width and thickness respectively 24 mm , 2 mm and 1 mm. EHD was generated by using a DC high voltage of 10 kV. Pin functional as an active electrode of corona discharge while the concentric rings Multi/single ring electrodes acted as ions collector and passive electrodes. In this model uses Kaptsov's assumption for boundary conditions between the ionization zone and the zone of the EHD flow and the magnitude of potential use Peek's formula. Modeling results showed that the electrical potential at the center of dual concentric rings smaller than the electric potential at the center of a single ring.

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Keywords: EHD flow zone, corona disharge, multi concentric ring electrodes

1. Introduction

An Electrohydrodynamic flow (EHD), also called wind "corona" , "electricity" , "ion" , or "ion propulsion" generated by the corona discharge significantly improved heat and mass transfer with significant [1] EHD flow can be applied to drug delivery system with EHD technique Sprying [2], applied as an integrated chip cooling technique

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for Laptop with EHD Pump [3-5]. EHD flow is another application for mikrofan [6] and as the dryer for the biscuit industry [7-8]. Devices that use ionic wind flow or EHD flow by corona discharge has many advantages such. EHD flow requires no moving parts and provides flexibility in the form of channels and free from mechanical vibration and acoustic noise .

Various attempts have been made to increase the flow rate and optimization of wind ions such as by modifying the electrode configuration, such as: Pin-ring electrode configuration of Ion Wind Generator [9], Parallel Wire Non-Field [10], wire-rod [11] and Pin-Kasa with the results obtained EHD flow rate is greater than Pin-Ring [12]. As for increasing the number of electrodes Pin has been done [13-14] are multipin-ring electrodes in a cylindrical tube. In this research study has been conducted EHD flow with electrodes configured Corona Discharge Pin-Multi Concentric Ring. Differences in this study with the study of Rickard et al. [15], Rickard et al. {16], Rickard et al. [9] and June et al [6] is the research they use a pin-ring electrode pairs while the proposed research will use an electrode pair Multi Pin-Ring Concentric. On the electrode configuration studied the wind gained increasing ion flow rate compared with pin-single ring configuration

Research EHD flow which have been carried out numerically [12-14] which states EHD flow equation is a system of nonlinear equations. In the non-linear equations, the electric potential *(V)* can be obtained after completing the Poisson equation. The purpose of the study is to obtain a model EHD Flow by positive corona discharge use the electrode configuration pin-multi concentric ring. Difference of this study with the study of [9,12,17] is the study of their use Pin-Ring electrode while the this research had use Pin-Multi Concentric Ring electrodes.

2. Mathematical model of EHD Flow

EHD flow generated by corona discharge is described by the following equation. Electric potential *(V)* in air is governed by the Poisson equation:

$$\nabla^2 V = -\frac{q}{\varepsilon_o} \tag{1}$$

where q is the space charge density and ε_0 is the dielectric permittivity of vacuum. Defined electrical potential of the electric field intensity E as

$$E = -\nabla\ V \tag{2}$$

Electric current flow in the drifting zone is a combination of three effects: conduction (ion motion under the electric field relative to the entire air flow), convection (transport of charge by air flow), and diffusion. Therefore, the current density J is given by

$$J = \mu_E E q + U q - D \nabla q \tag{3}$$

Where μ_E is the mobility of air ions in an electric field, U is the air velocity vector, and D is the diffusion coefficient of Current continuity condition gives the equation for the current density

$$\nabla . J = 0 \tag{4}$$

Hydrodynamic problem of EHD flow is described by the Navier-Stokes equations and the continuity equation for steady state flow of compressed air:

$$\rho U_i . \nabla . U = -\nabla p + \mu \nabla^2 U - q \nabla V \tag{5}$$

$$\nabla . U = 0 \tag{6}$$

Where ρ is the density of air, p is the air pressure, and μ is the dynamic viscosity of air. By substituting the expression for the current density in equation (3) into equation (4) and pay attention to the record definitions of electric potential as in equation (1) and the continuity equation for the air velocity (6) one can obtain the following charge transport equation:

$$\nabla.(-D\nabla q-\mu_E\nabla Vq)+U.\nabla V=0 \quad (7)$$

For the electric potential Vp and Vc on the surface of the electrode pin and ring electrode surface and when the pin electrode radius is much smaller than the distance between the electrodes, the ionization zone formed uniformly on the surface of the electrode sheath pin. At the boundary between the ionization zone and the zone of flow of charge (drifting), the electric field strength at the breakdown electric field strength in the air E_0 = 3.23. 10^6 V / m, according to the assumption Kaptsov .

For positive corona, the strength of the electric field E_p at the pin radius R_p is given by the empirical formula Peek to air at standard conditions .

$$E_p = E_0(1+2{,}62.10^{-2}/\sqrt{R_0}) \quad (8)$$

Where the radius of the wire is measured in mm

Unlike the drifting zone, negligible space charge density in the ionization zone. So, assuming that the electric field strength is inversely proportional to the distance from the center pin can easily find the external radius of the ionization zone

$$R_p = R_0(1+2{,}62.10_{-2}/\sqrt{R_0}) \quad (9)$$

and the electrical potential at the external boundary of the ionization zone

$$V_0 = V_p - E_pR_p\ln\frac{E_p}{E_0} \quad (10)$$

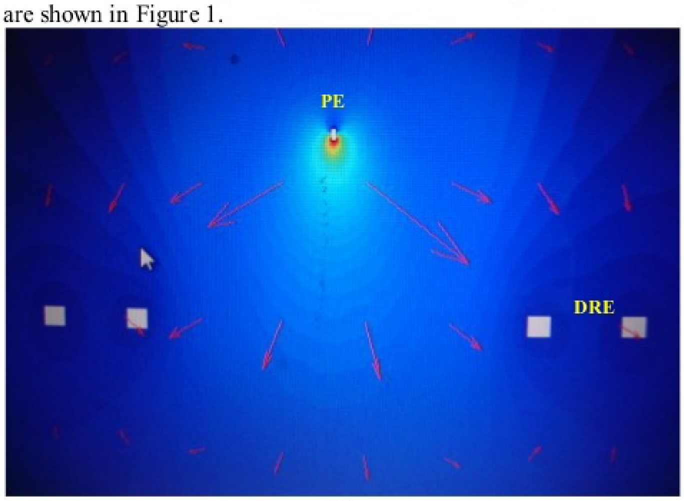
Therefore, the Poisson equation for the electric potential (1) is to be completed only in the drift zone is determined by the voltage V_0 at the external boundary of the ionization zone.

For charge transport equation (7), also completed in just a drifting zone, defined diffusive flux conditions, *dq / dn = 0*, on all surfaces except the external boundary of the ionization zone. The validity of this assumption is justified by the fact that the outflow boundary conditions for the charge density is needed only when the diffusion rate is present in (7), which has negligible effect on the charge density distribution in the corona current modeling [4]. On the external surface of the ionization zone we use the assumption Kaptsov[16]. which did not give a direct description of the meeting determines the charge but the electric field strength.

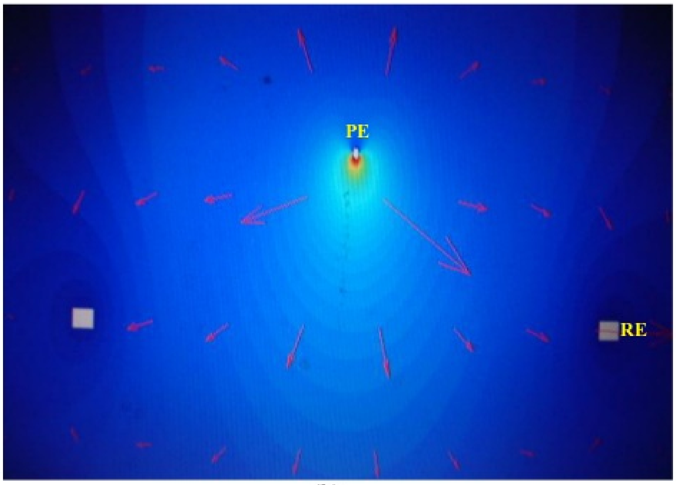
3.Result

The electric potential distribution in EHD flow zones has been done through modeling using pin-multi concentric rings electrodes and being used pin-ring electrode as comparator. A tip pin elecrode has diameter of 0.01 mm. Pin-multi concentric rings electrodes was constructed by double concentric rings connected to each other and which each ring has a diameter of 24 mm and 16 mm in width and thickness of the same ring is 2 mm and 1 mm. The ring electrode has a diameter, width and thickness 24 mm, 2 mm and 1 mm, respectively. The spacing between electrodes is 10 mm. EHD is generated using high voltage DC 10 kV. Pin as an active electrode corona discharge and multi concentric rings / ring electrode as the ion collector and passive electrodes. From the results of simulation modeling of electic potential distribution will be obtained magnitude of the electric field E or the electric flux density in the zone of the EHD flow. EHD flow that uses electrodes Multi pin-multi concentric ring will happen electric flux density greater than Pin-Ring electrode. With great power flux density will lead to increased space charge density. Ion movement towards multi-ring electrode will collide with neutral air molecules with very high collision frequency. Large momentum transfer from the gas molecules to the positive ions in the region between the electrodes will be able to enlarge EHD flow .

Numerical simulation of this modeling uses Kaptsov assumptions for the boundary conditions between the ionization zone and zone EHD flow and the electric potential magnitude of Peek's formula results obtained by modeling. The corona pin of radius 0.01 mm is positioned in the middle of the domain. From (9) the external radius of ionization zone is $_0R$ =0.13 mm and electric potential on the external boundary of the ionization zone (10) V_0=9,876286 kV. Numerical simulations using the length and width of computation domains is 18 cm and 12 cm. Results from simulations are shown in Figure 1.



(a)



(b)

PE=Pin electrode
RE= Ring electrode
DRE=Dual Concentric Ring electrodes

Figure 1 Electric potential distribution and direction of the electric field .(a) configured electrode pin- dual concentric ring (b) configured electrode pin- ring.

Based on the electrostatic theory, the total electric potential is sum of several electrical potential caused by the charge/source nearby. In this the simulation modeling, the high potential subjected pin electrodes and multi/singles ring electrode functional as graund. Then the total electric potential along the axis of the pin-ring electrode is more greater than with using a pin-multi consentric ring electrode. This is due to the additional the value zero (ground) of electric potensial of the inner ring of multi concentric ring.

From the figure 1 information about equipotential field and the direction of the electric field. Direction of the electric field spread from the corona electrode and they will accumulate to ring electrodes. The electric potential distribution along the axis can be obtained. The results of curve fitting of electric potential distribution along the axis is an exponential function as shown in Figure 2

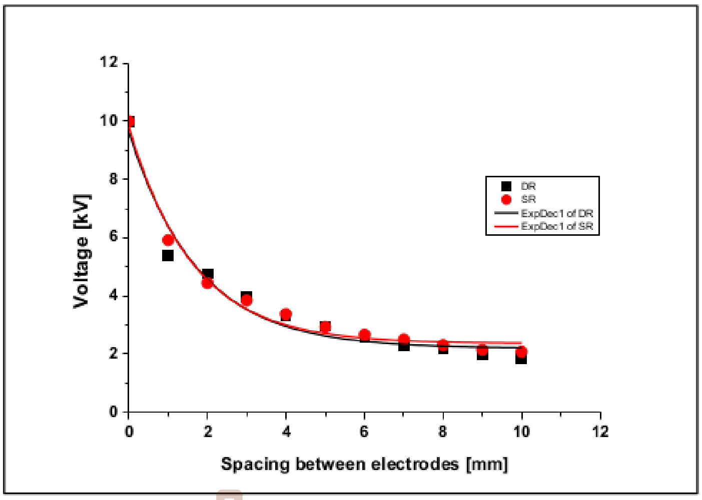


Figure 2 Electric potential distribution along the axis.

The electric potential at the center of a dual concentric ring is larger than the electric potential at the center of a single ring. And the electric potential which will be zero for infinite area.

4. Conclusion

Modeling of the electric potential distribution in EHD flow zones using pin-mult concentric rings electrodes and pin-ring electrode as comparator have been done. The electric potential at the center of a dual concentric ring is larger than the electric potential at the center of a single ring. The results of curve fitting of electric potential distribution along the axis is an exponential function.

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